### Sub-atomic Measurements

To detect the stellar wobble movement caused by a planet as small as Earth, scientists need an instrument of almost unbelievable sensitivity. In order to do that, the instrument needs to be accurate to within just one-tenth of the width of a hydrogen atom. That's about 1 millionth of the width of the thickest human hair!

After a six-year struggle, engineers at the Jet Propulsion Laboratory (JPL) recently proved that such precision is possible. Such sub-atomic measurements were conducted for the first time ever within a vacuum-sealed chamber called the Microarcsecond Metrology Testbed. The engineers proved they can measure the movements of stars with an astonishing degree of accuracy never before achieved in human history.

Because even small air movements can interfere with the measurements, all air is pumped out of the chamber before each experiment is run. Laser beams, moving mirrors, and a camera are used to simulate the light that would be emitted by a real star.

The instrument will become the heart of a revolutionary new space telescope known as the Space Interferometry Mission, managed by JPL as part of NASA's Origins program. Scheduled to launch in 2009, it will scan the heavens for five years and provide astronomers with the first truly accurate road map of our Milky Way Galaxy, measuring cosmic distances several hundred times more accurately than currently possible.

*- from "Tiny Measurement Gives Big Boost to Planet Hunt," PlanetQuest, 7/22/03*

☑ YOUR PREPAREDNESS FOR AN AUDIT OF NASA METROLOGY AND CALIBRATION REQUIREMENTS WITH THESE SAMPLE AUDIT GUIDE QUESTIONS.

**MANAGEMENT:**

1. Which Center is responsible for developing, implementing, and approving the Metrology and Calibration Program Plan?
2. To what standards must suppliers of calibration laboratory services be compliant and accredited?

**GENERAL:**

1. Where can you obtain your Center's Metrology and Calibration Plan or Program?
2. Who is your Center designated representative to the NASA Metrology and Calibration Working Group (MCWG)?
3. When can non-calibrated instruments be used? How does your Center limit the use of non-calibrated instruments to acceptable applications?
4. For what applications do you use calibrated instruments?

NASA Office of Safety and Mission Assurance
300 E Street SW
Washington DC 20024-3210
Phone (202) 358-0521
www.hq.nasa.gov/office/codeq

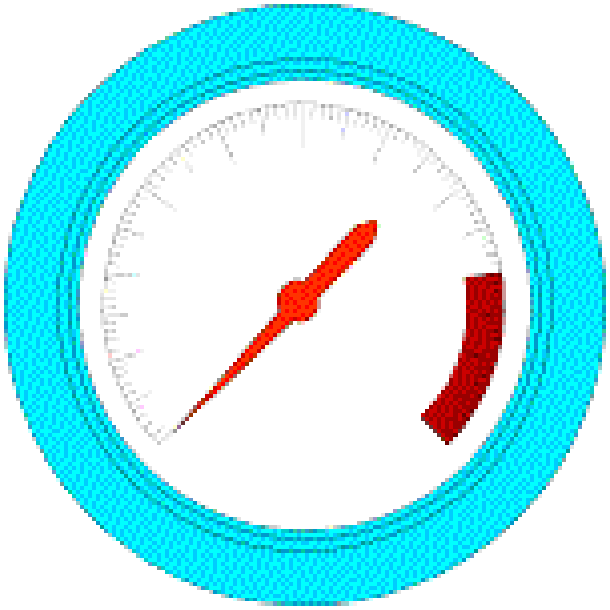
Publication Date March 23, 2005

NASA
SAFETY AND MISSION ASSURANCE REQUIREMENTS

# NPD 8730.1

# Metrology and Calibration

## Compliance Verification Guide



OFFICE OF SAFETY AND MISSION ASSURANCE

This brochure is intended to be used as a guide only, not as a replacement for the actual policy. To review Metrology and Calibration (NPD 8730.1) in its entirety, see http://www.hq.nasa.gov/office/codeq/doctree/texttree.htm.

**Does your job require the use of calibrated tools or equipment?**

- If so, how do you know if they are calibrated?
- If calibration is necessary, what is the process to accomplish it?

## Metrology and Calibration

Maintain calibration of all test and measuring equipment and safety instruments associated with the following:

- Acceptance testing (determining that a part, component, or system meets specifications).
- Inspection, maintenance, or calibration.
- Flight hardware qualification.
- Measurement of processes where test equipment accuracy is essential for the safety of personnel or the public.
- Telecommunication, transmission, and test equipment where exact signal interfaces and circuit confirmations are essential to mission success.
- Development, testing, and special applications where the specifications, end products, data or instruments are used in hazardous and critical applications.

## NASA Metrology and Calibration Working Group (MCWG)

A technical forum to discuss Agency policy and issues common to all standards and calibration operations and to recommend research projects that meet the present needs and future strategic goals of NASA.

# MINIMUM AUDIT POINTS FOR NPD 8730.1

## Leadership & Management

- **Chief Safety and Mission Assurance Officer**
  - Designates a responsible Center for the Agency for developing and implementing the Metrology and Calibration Program Plan.
    - Objective Quality Evidence (OQE) - Metrology and Calibration Program Plan
  - Approves the Metrology and Calibration Program Plan and metrology and calibration operating plans and authorizes specific policies and requirements as identified therein.
    - OQE – Metrology and Calibration Plan
  - Authorizes the charter and resources for the NASA MCWG.
    - OQE – MCWG Charter and Resources
- **Center Directors**
  - Designate a representative from the Center to the NASA MCWG ensuring representation at the annual MCWG workshops as well as representation at other appropriate industry-related symposia and government agency metrology and calibration meetings.
    - OQE - MCWG Participant List, Meeting Attendance Lists
  - Implement and monitor use of this NPD at their respective NASA Centers and component facilities.
    - OQE - Metrology and Calibration Program Plan, Internal Audit Records

## Core Process

- **NASA Programs and Laboratories**
  - Require suppliers of calibration laboratory services to be compliant with the calibration laboratory competency requirements identified in ANSI/NCSL Z540.1-1994 (R2002).
    - OQE - Supplier Accreditation Certificate
  - Require suppliers of calibration laboratory services be accredited to ANSI/ISO/IEC 17025:2000, where it is appropriate and beneficial to NASA and be compliant with the calibration laboratory competency requirements identified in ANSI/NCSL Z540.1-1994 (R2002).
    - OQE - ANSI/NCSL Z540.1-1994 (R2002)
  - Maintain calibration on all test and measuring equipment and safety instruments used to perform measurements.
    - OQE – In-process Inspection Results
  - Limit use of non-calibrated instruments to applications where substantiated accuracy is not required, or for "indication only" purposes in non-hazardous, non-critical applications.
    - OQE – Policy/Procedure on Instrument Use

## The Role of Measurement in the Hubble Space Telescope (HST)

Meant to be one of the most precise telescopes ever made, the 1990 launch of the $2.5 billion telescope was almost a flop. Instead of directing light at the HST surface using lenses, the device employs a pair of carefully calibrated mirrors. The HST uses lasers instead of just ordinary light. The HST was to be capable of measuring the mirror surface to better than one one-thousandth of a wavelength in micrometers.

It appears that when the mirror was being polished to the right shape by the manufacturer, the device used to test its curvature, called a null corrector, had been made to the wrong specifications. When the null corrector showed that the HST mirror was as close to perfect as it could be, it was actually ever so slightly the wrong shape.

The manufacturer could have corrected the error before it was too late, but the optical team dismissed the warning signs. The first indication of trouble appeared as they were assembling the null corrector. As they tried to move the errant lens into position, they found that the lens adjustment screws would not turn far enough. The opticians were probably taking incorrect readings from a high-precision measuring rod. Instead of trying to find the problem, they simply added some 1.3 millimeter thick spacers to extend the lens range of motion. Once they were done, they treated this null corrector as being "certified" correct. A final warning sign appeared after the polishing of the mirror was completed. As the opticians were checking the mirror's overall curvature with yet a third null corrector, once again, the test pattern showed spherical aberration, and again the results were dismissed in favor of the "certified" device.

When the servicing mission to install the corrective optics was successfully completed, the HST was restored to 97% of its promised operational capabilities.